

Names _____
(Prior coordination with me is required if more than two of you work together on this project)

Section _____

PHYSICS 315 –COMBAT AVIATION PHYSICS

Spring 2002

Application Exercise 4

Pulsed Spectra

Due: Beginning of class, lesson 30
100 points

This application exercise is graded. To receive full credit you must show all work and communicate efficiently using proper grammar.

AUTHORIZED RESOURCES: *any published or unpublished sources and any individuals.*

Document appropriately!

Objective:

The objective of this application exercise is to explore and learn the effects of pulse width, number of pulses (pulse train length), and pulse repetition frequency on the frequency spectrum of a pulsed radar signal.

Overview:

The attached graphs are the output of a MathCAD program used to model radar pulses. The program uses a Fourier transform for the analysis and presents the results on a time domain graph and a power vs. frequency spectrum.

Since realistic numbers for RF, PRF, PW and pulse train length would leave us with unmanageable and difficult to read graphs, we'll use a carrier frequency of 5 Hz, PRFs on the order of tenths of Hz, PWs on the order of seconds, and pulse train lengths on the order of several seconds. Although unrealistic in magnitude, we will still be able to get a qualitative appreciation for the effects of these variables on a radar signal's spectrum.

For each output graph, the pulse width, the number of pulses, and the pulse repetition interval are in some way varied. The values for these variables are found below each graph.

Each top graph is a plot of the amplitude of the signal as a function of time. Each lower graph is a plot of the power as a function of frequency (power spectrum). The units for time are seconds, frequency is measured in Hz, and the units for amplitude and power are arbitrary.

Answer the questions below, attach your answers to the included graphs, and turn the whole package in by the due date above.

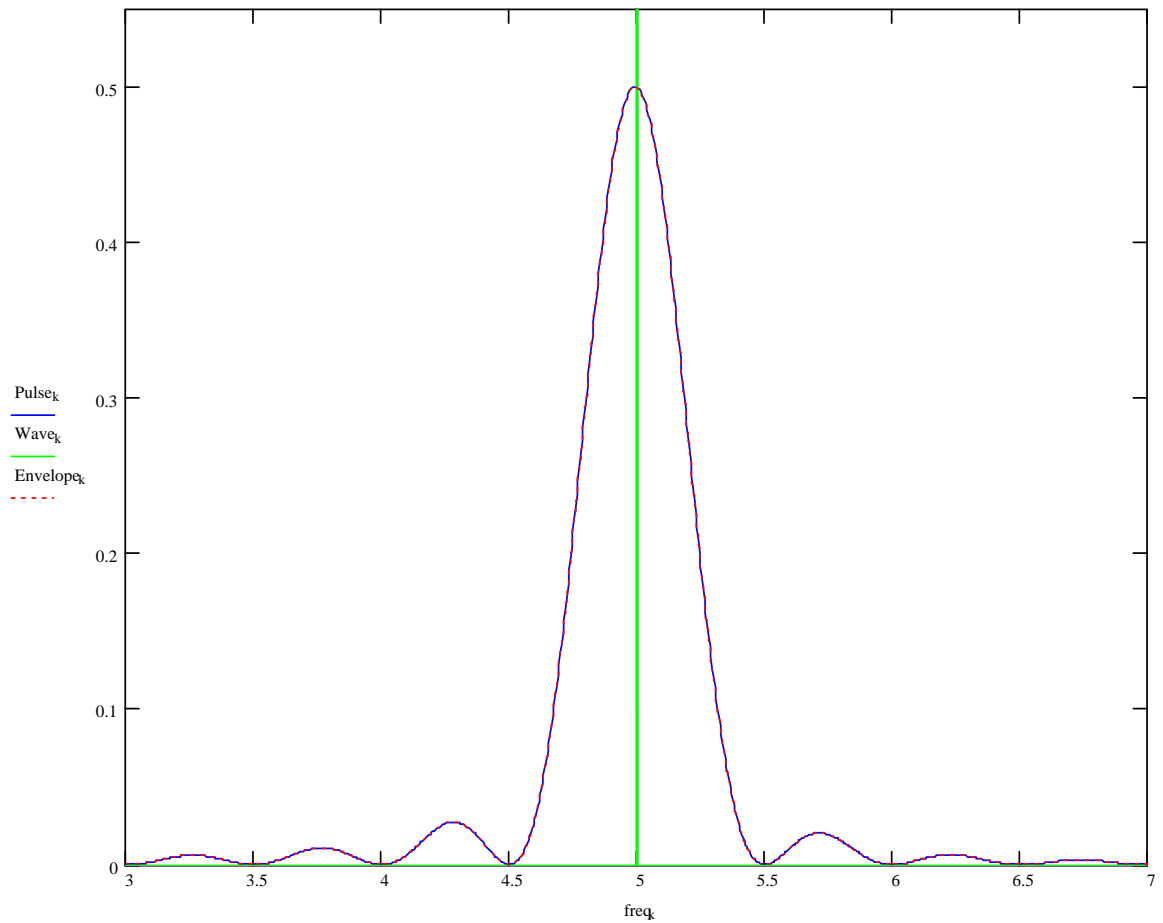
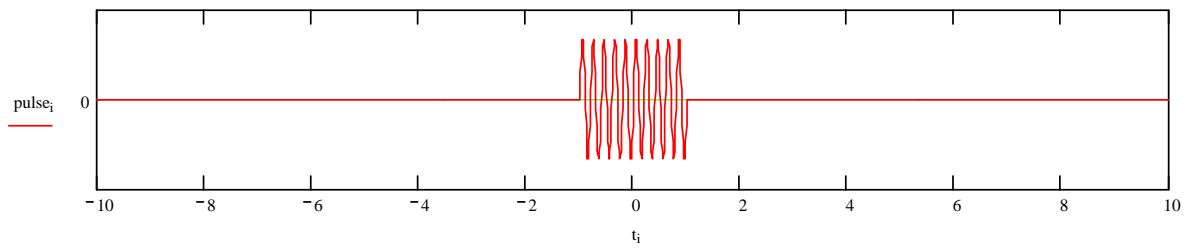
Analysis:

1. The first two pages demonstrate the effect of varying PW for a single pulse.
 - Label the PW on each time domain plot
 - Label the null-to-null bandwidth (BW_{nn}) and peak power on each frequency spectrum.
 - What happens to the bandwidth as the pulse width increases?
 - What is the mathematical relationship between pulse width and bandwidth?
 - If I double the pulse width, by what factor does the **peak** power (at 5 Hz) change? Why?
2. The next two pages demonstrate the effect of varying the PRI (hence PRF) for a constant number of pulses with constant PW.
 - Label the PW and PRI on each time domain.
 - Label the BW_{nn} and PRF on each frequency spectrum. (Note that BW_{nn} refers to the shape of the envelope, not the individual lines)
 - What is the mathematical relationship between PRI and PRF?
 - What is the mathematical relationship between line spacing and the PRF?
 - What is the effect of changing the PRF on BW_{nn} ?
3. The next two pages demonstrate the effect of varying the total number of pulses (hence the pulse train length) while maintaining a constant PW and PRI.
 - Label the PW, PRI, and pulse train length on each time domain.
 - Label the BW_{nn} , the null-to-null line width (LW_{nn}), and the max power at the carrier frequency on each spectrum.
 - What happens to the frequency spectrum as the pulse train length increases?
 - What is the mathematical relationship between line width and total number of pulses?
 - If I double the pulse train length, by what factor does the peak power at the carrier frequency change? Why?
 - What is the effect of changing the number of pulses on the BW_{nn} ?
4. The final two pages each show a pulse train length of 18 seconds [number of pulses N times PRI]. The PW is adjusted to give each pulse train the same total energy.
 - Explain what happens to the BW_{nn} , LW_{nn} , line spacing, peak power at the carrier frequency, and total number of spectral lines within the main bandwidth?
 - BW_{nn} changed between the two graphs. Changing which parameter caused it to change?
5. Often the Doppler shift we want to be able to detect is much finer than the bandwidth of a single pulse (see graph #1). Our ability to detect a small Doppler shift is known as Doppler resolution.
 - How can we change the features in the frequency spectrum to improve Doppler resolution? Include LW_{nn} and line spacing in your discussion. What are some disadvantages of taking these steps to improve Doppler resolution?

Answer the following question for up to 25 IP points:

6. Let's say you are using a 10 GHz carrier frequency, 1 KHz PRF, 1 μ s PW, and 0.5 sec pulse train length.
 - What is your line spacing?
 - Based on your answer above, what is the greatest Doppler shift (Hz) you can detect before your main band moves into the position formerly occupied by the first adjacent sideband?
 - What is the relative closure velocity that corresponds with this Doppler shift?

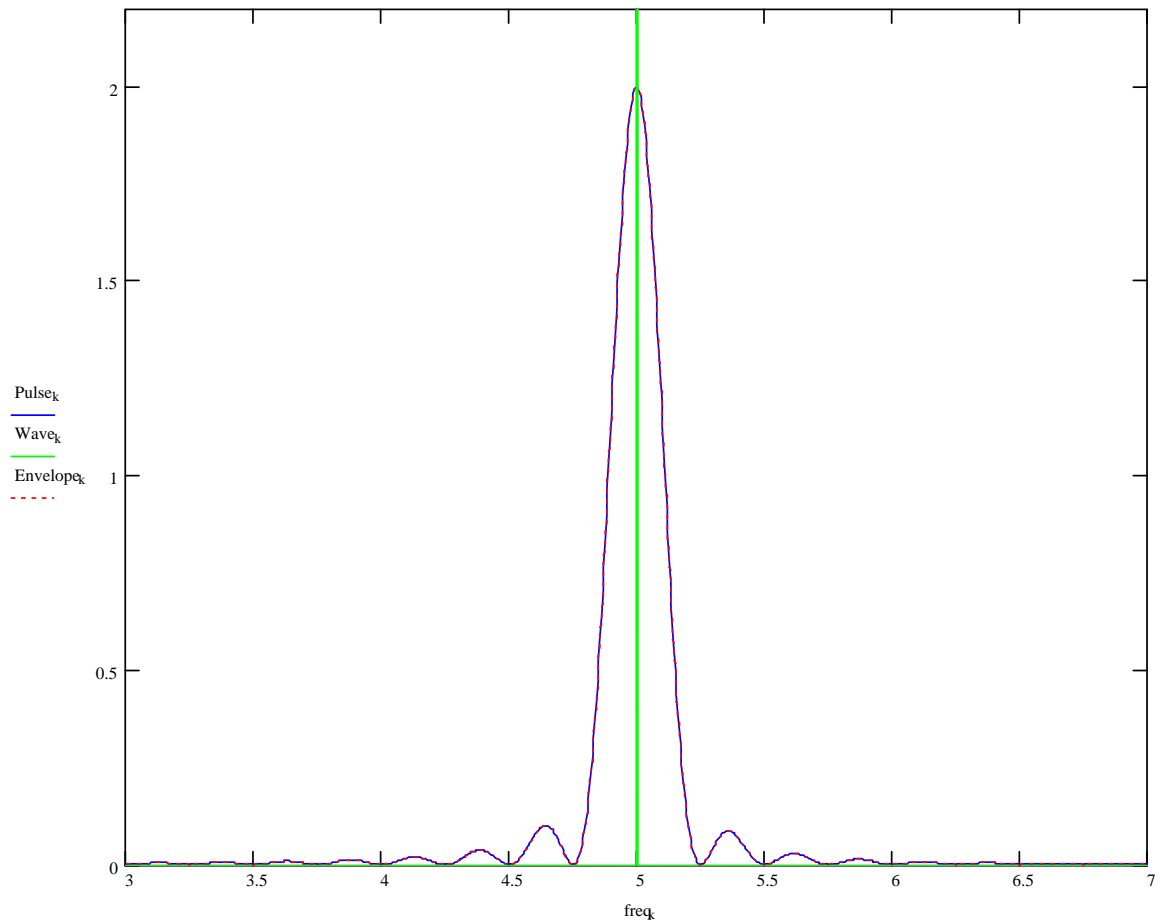
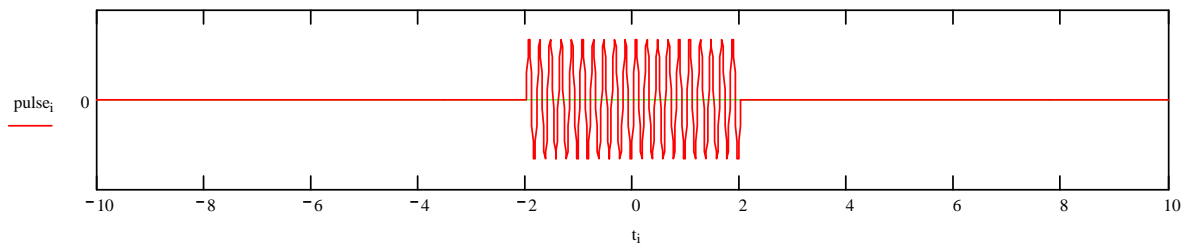
When your Doppler shift exceeds this value, you must consider the possibility of Doppler ambiguities, as we will discuss in class next lesson.



Pulse_Width = 2

Number_of_Pulses = 1

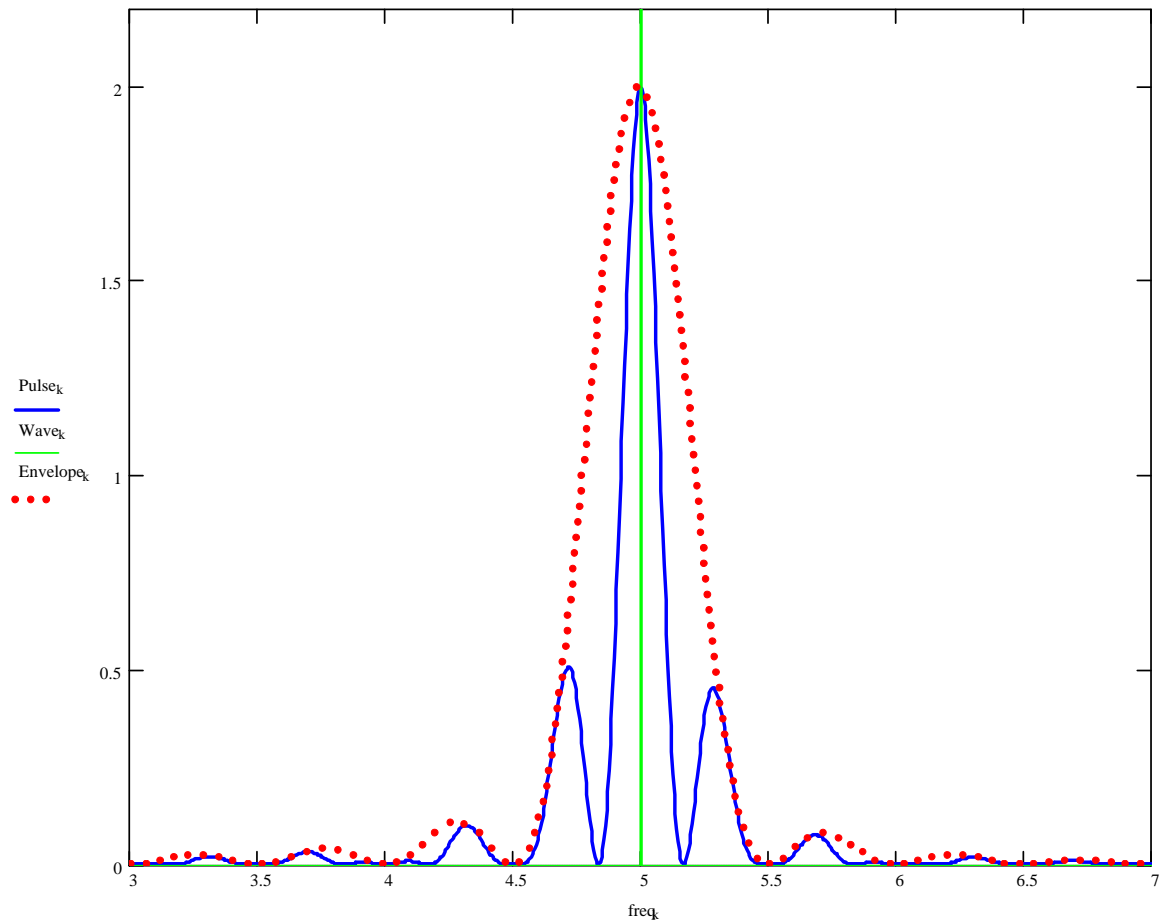
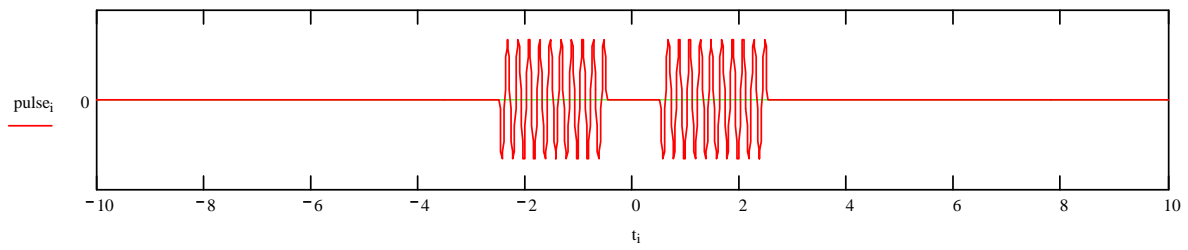
Pulse_Repetition_Interval = 1



Pulse_Width = 4

Number_of_Pulses = 1

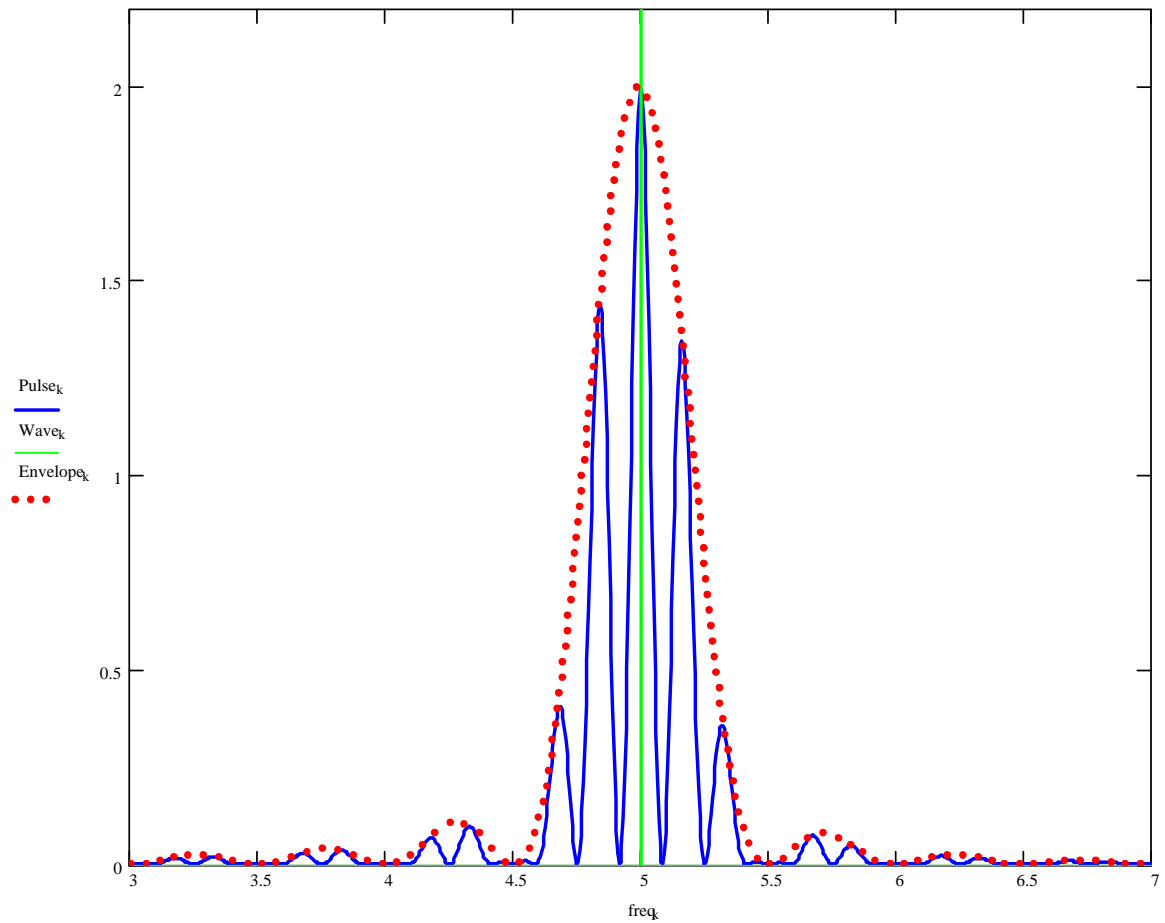
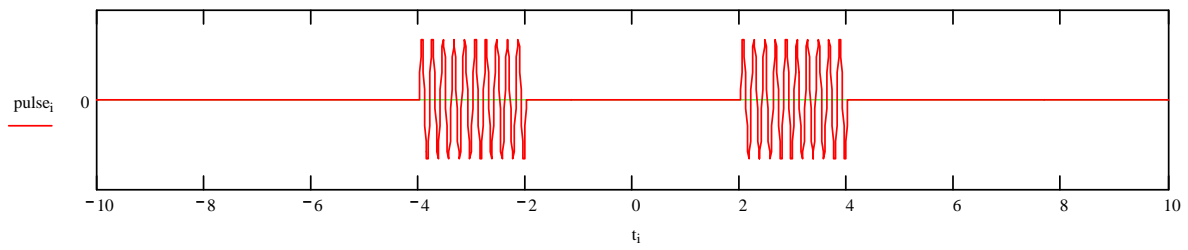
Pulse_Repetition_Interval = 1



Pulse_Width = 2

Number_of_Pulses = 2

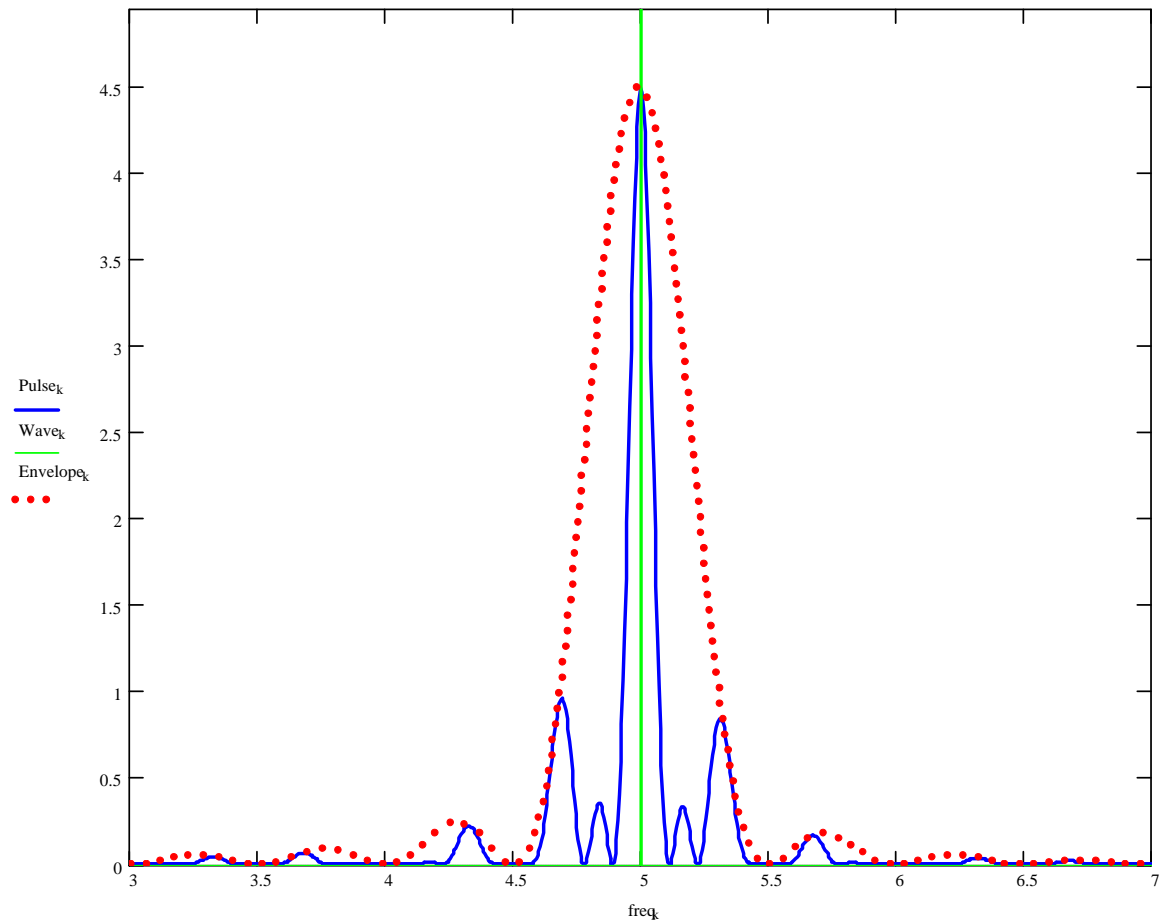
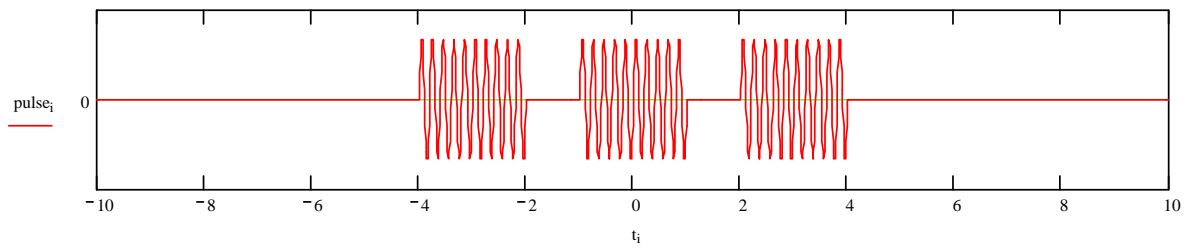
Pulse_Repetition_Interval = 3



Pulse_Width = 2

Number_of_Pulses = 2

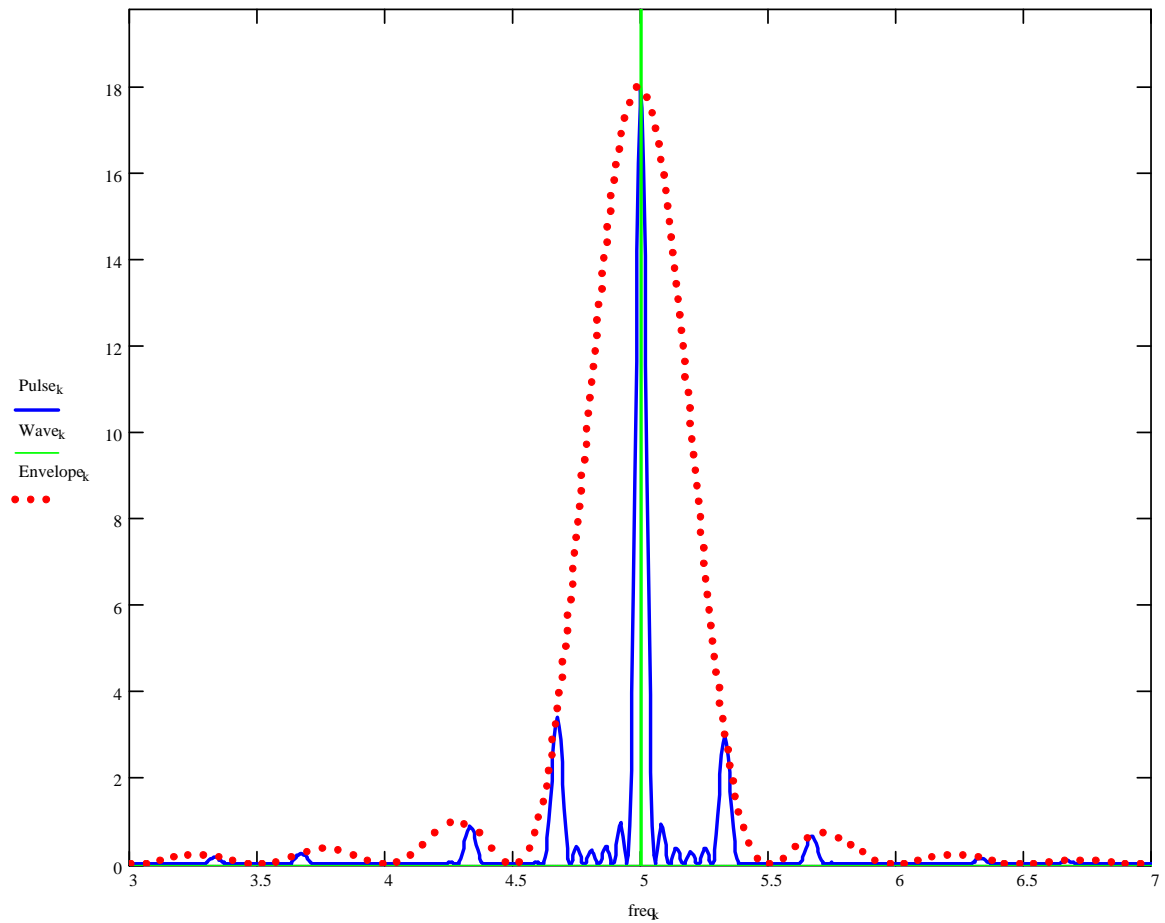
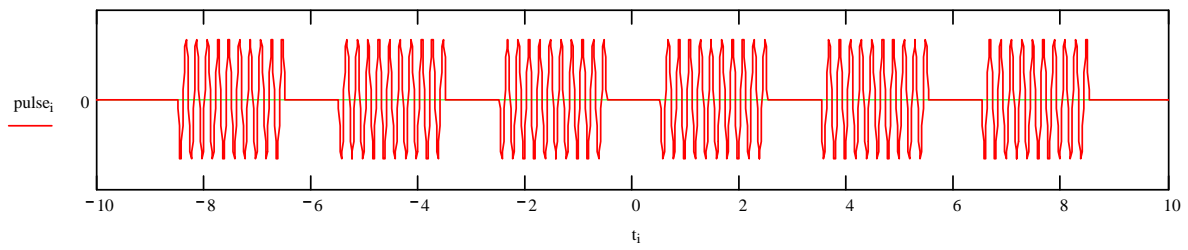
Pulse_Repetition_Interval = 6



Pulse_Width = 2

Number_of_Pulses = 3

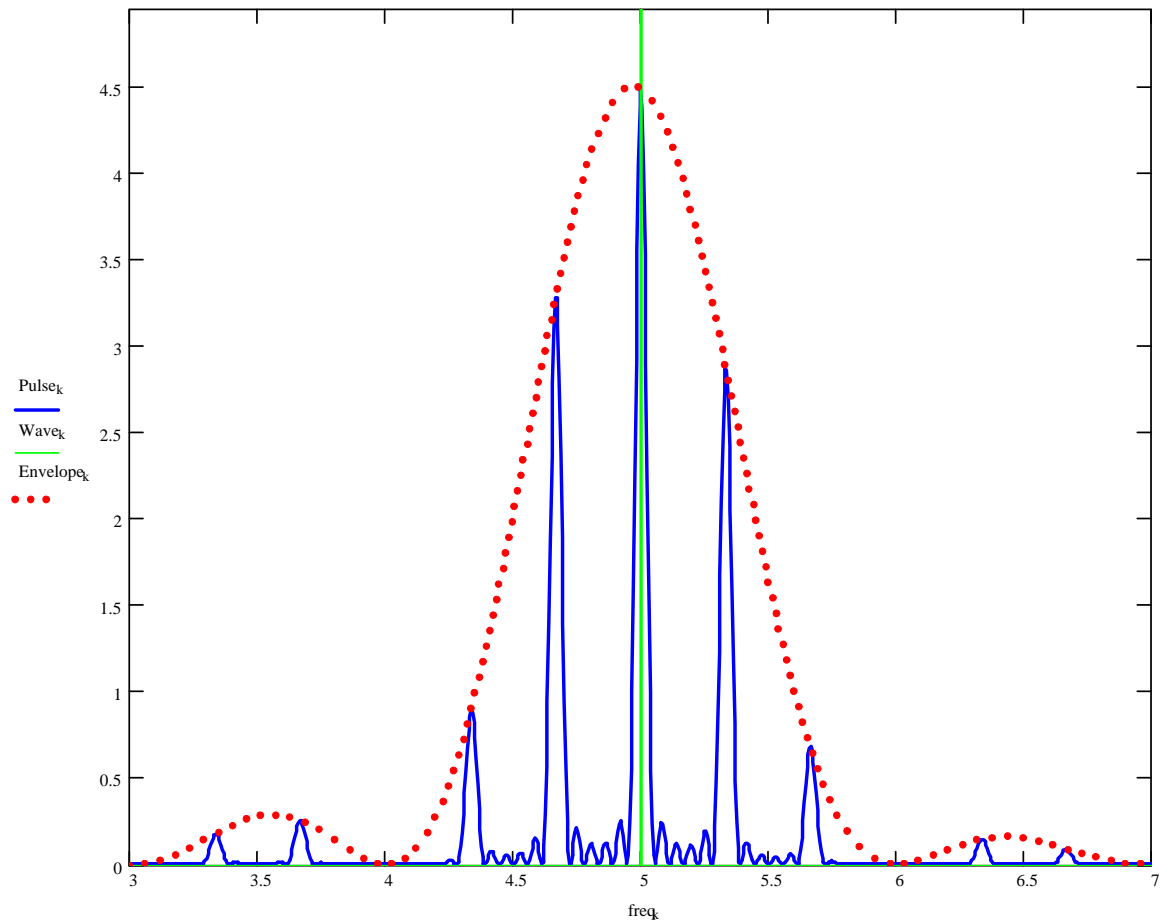
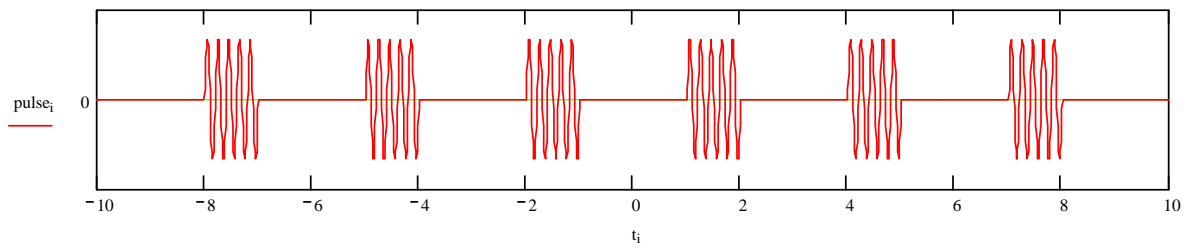
Pulse_Repetition_Interval = 3



Pulse_Width = 2

Number_of_Pulses = 6

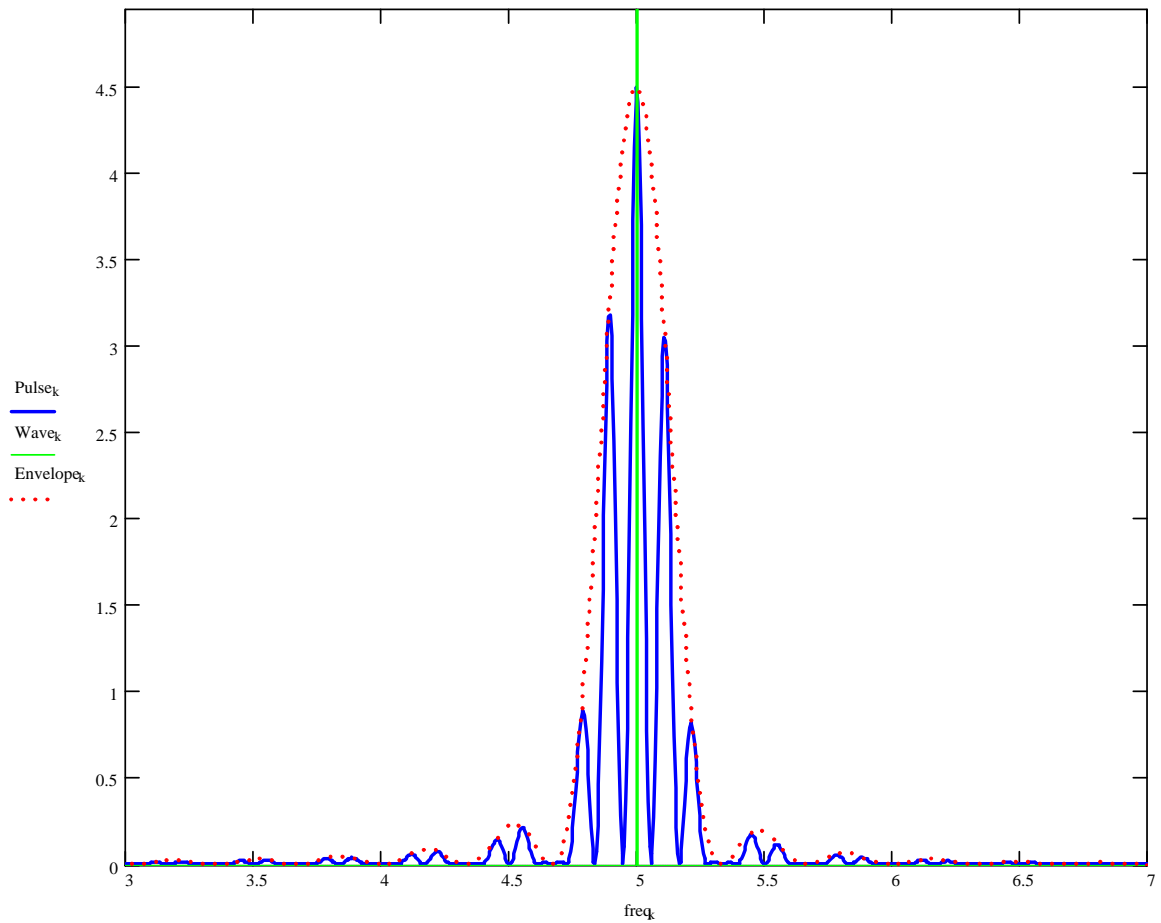
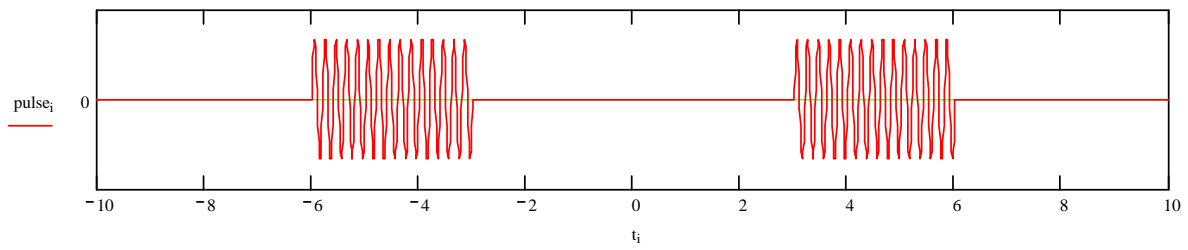
Pulse_Repetition_Interval = 3



Pulse_Width = 1

Number_of_Pulses = 6

Pulse_Repetition_Interval = 3



Pulse_Width = 3

Number_of_Pulses = 2

Pulse_Repetition_Interval = 9